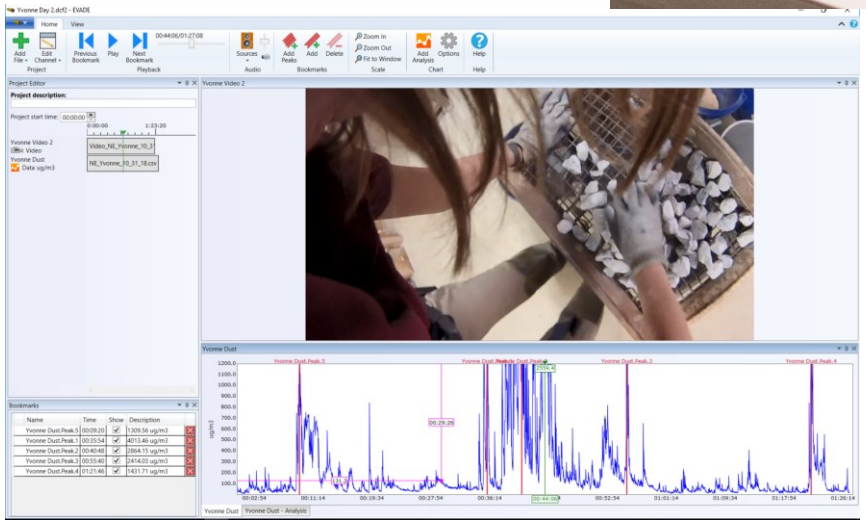
Field-based Silica Monitoring Methods



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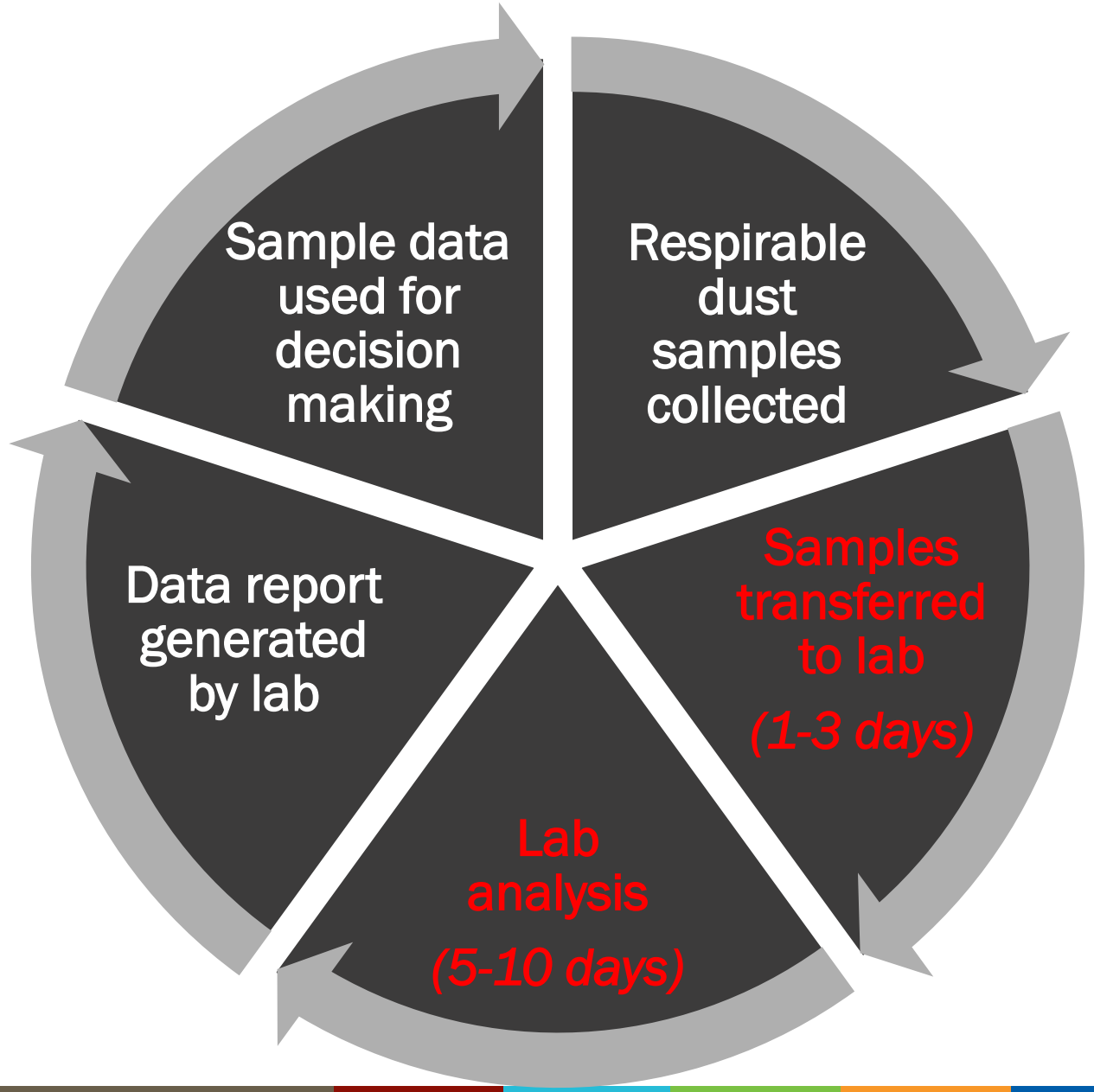
NIOSH Center for Direct Reading and Sensor Technologies

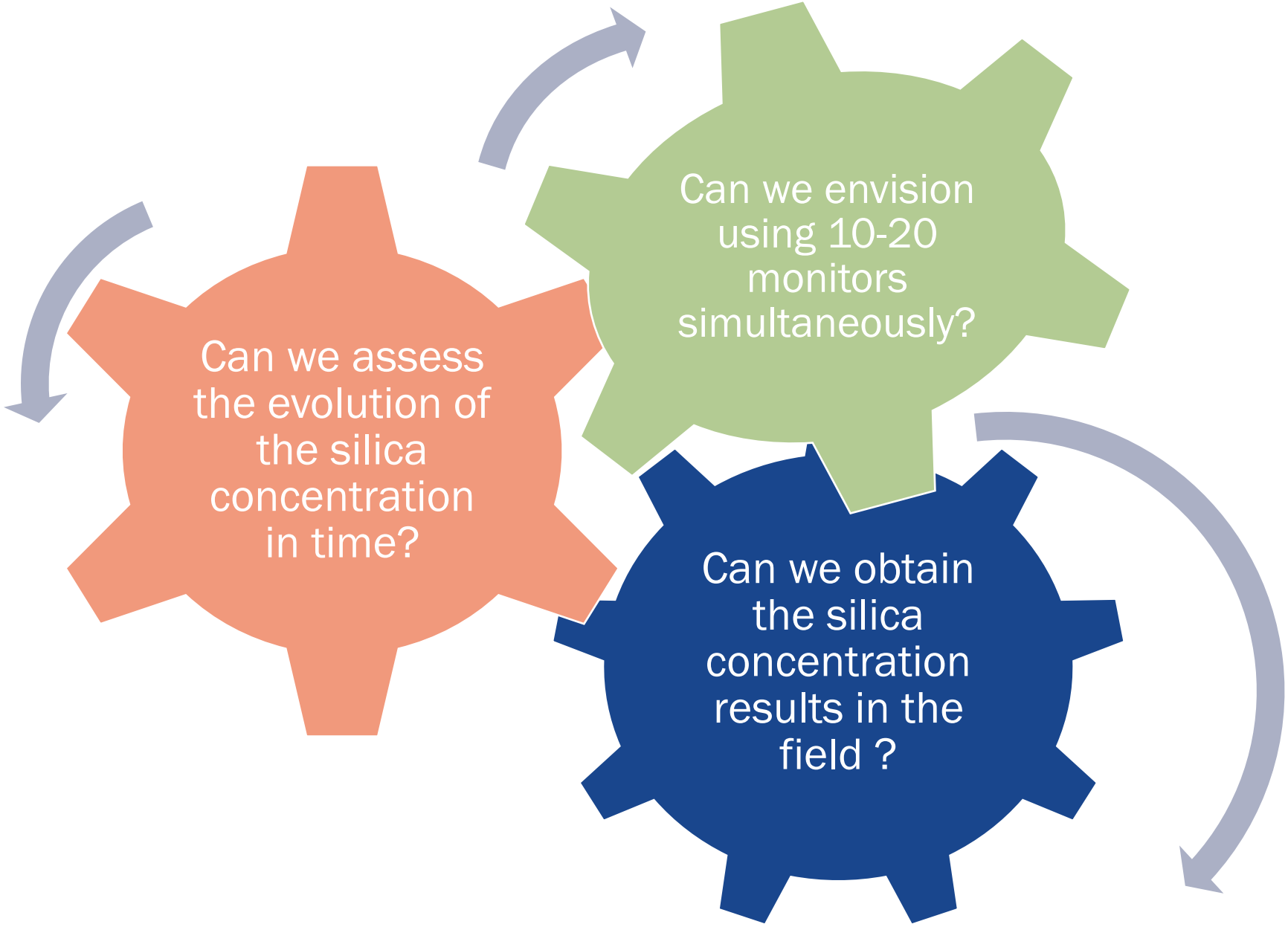
Traditional silica exposure monitoring in the workplace

Challenges

- Workplace conditions may change faster than results are available
- A lot of work for a single datapoint
- Additional samples → *additional costs*



Advanced silica exposure monitoring in the workplace

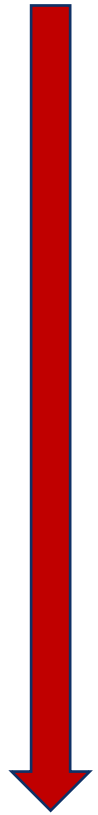


Process for the use of (advanced) silica exposure monitoring

Definition of the objective/goal for conducting a session with an advanced technique

Understanding the functionality of each component of the technique

Competence on the capabilities and limitations of the technique and data



Data

Information

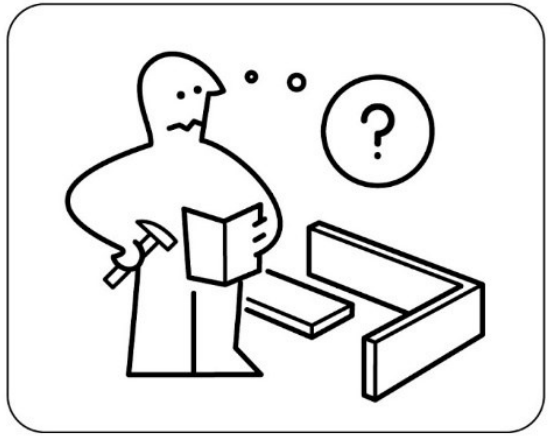
Knowledge

Right Sensors/Methods Used Right

An initiative of the Center to promote the competent development, selection, adoption, and data interpretation of real-time monitors and direct-reading methodologies

Right Sensors – It is much more than picking the right gadget. It is a proper analysis of the specific IH need, the definition of objectives and hypothesis.

Used Right– It is not enough to read (??) a manual of a device. It is the need to understand the capabilities and limitation of the technology and data generated.



https://blogs.cdc.gov/niosh-science-blog/2019/05/16/right-sensors-used-right/

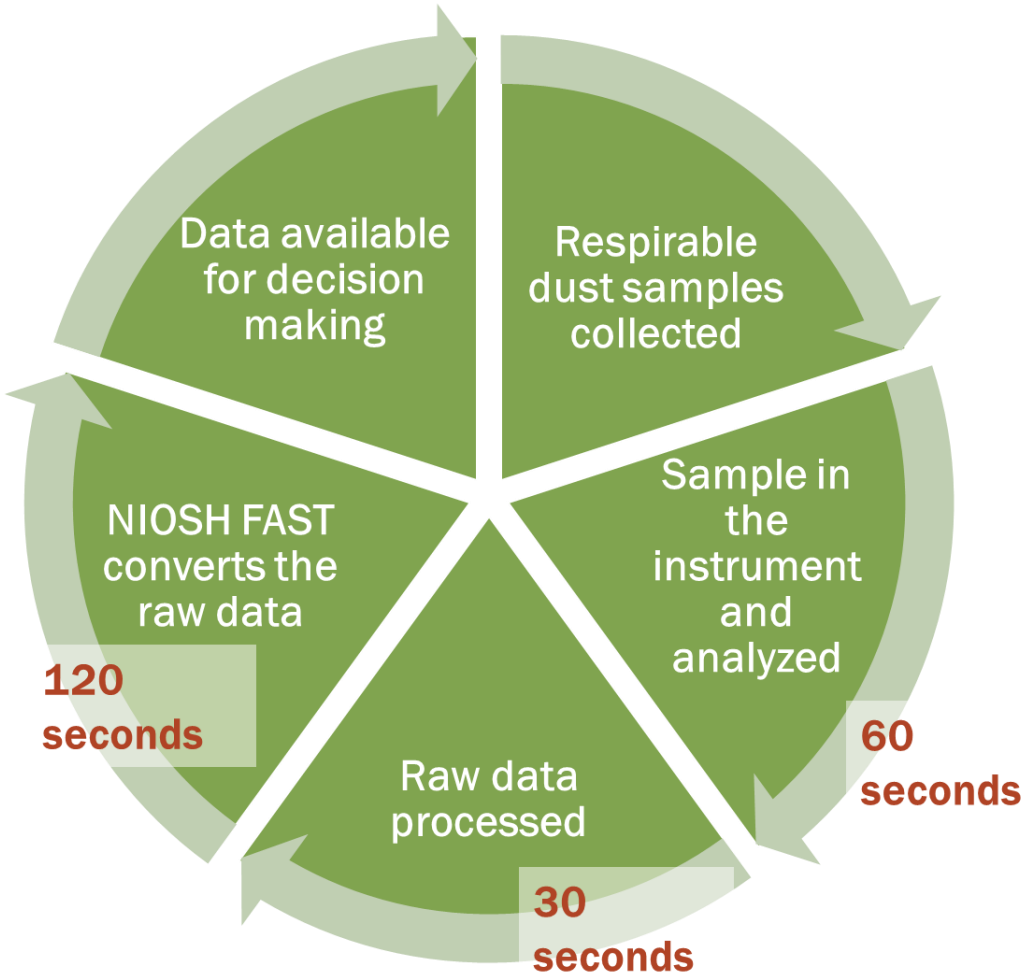
A field-based approach allows end-of-shift silica monitoring

Main characteristics

- A small laboratory in the field
- Specific to respirable crystalline silica (not dust)
- Portable and non destructive analysis
- Easy to use by non-experts in analytical methods

A proactive tool

- Assessment of RCS exposure/concentration
- Identification and implementation of work practices
- Evaluation of engineering control technologies
- Complementary tool in support of compliance



Field-based silica monitoring approach using a portable FTIR analyzer

A 3 steps process with optional lab verification

Collect samples using gravimetric dust samplers

Analyze samples with a portable FTIR unit

Process the FTIR data with NIOSH FAST software

(optional) Verify field analysis with laboratory tests

FAST
Field Analysis of Silica Tool

Field-based silica monitoring approach

Adoption of commonly used industrial hygiene dust sampling techniques

Many respirable dust samplers can be used with this monitoring approach (*flexibility*)






A novel sampling cassette was designed to facilitate the analysis and minimize losses (*user friendly*)




Minimal changes to industrial hygiene practices

Field-based silica monitoring approach

Portable analyzers and a new NIOSH software

FAST
Field Analysis of Silica Tool

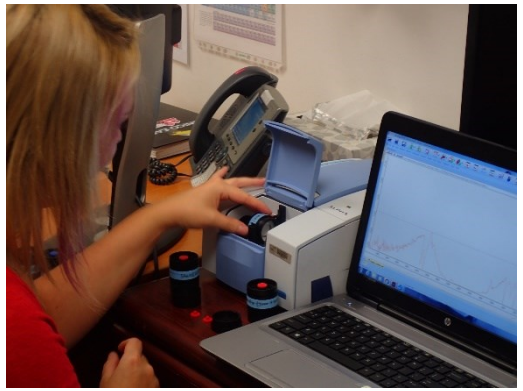
From portable FTIR

- Raw data for silica in samples

Required metadata

- Sampling duration
- Sampler type
- Filter size
- Average flow rate

Silica concentration



https://www.cdc.gov/niosh/mining/works/coversheet2056.html

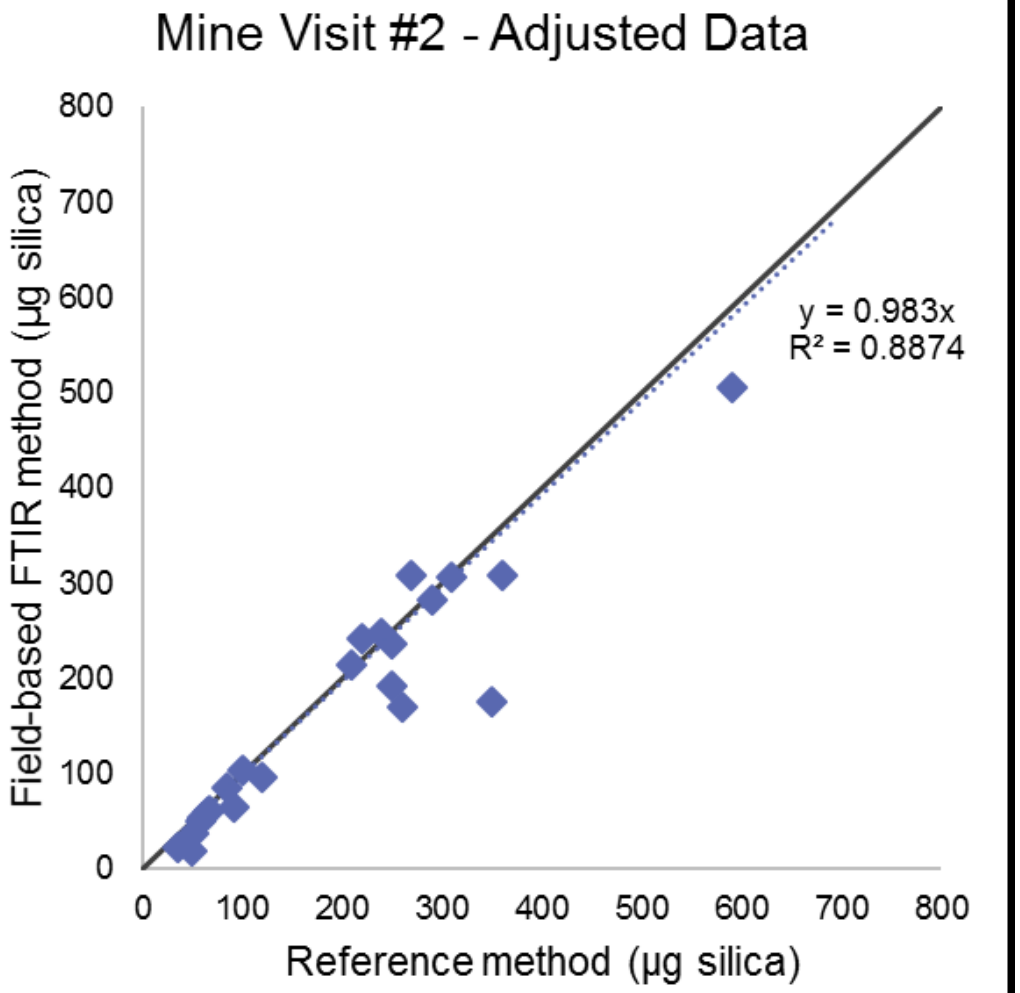
Field-based silica monitoring approach

How accurate is the estimation?

Creating a site specific correction factor

- The monitoring approach detects silica in samples collected in mining and non-mining environments.
- The accuracy of the analytical method for samples collected in a coal mine is very good. Positive impact to fight CWP (black lung) in coal mines.
- The quality of the estimation for samples collected in non-coal mines and other workplaces - *oil&gas, construction, manufacturing* - is variable and NIOSH is working on multivariate predictive models.
- ***Best practice*** - create a site-specific correction factor.

3 Apply knowledge of the training data to the sample set

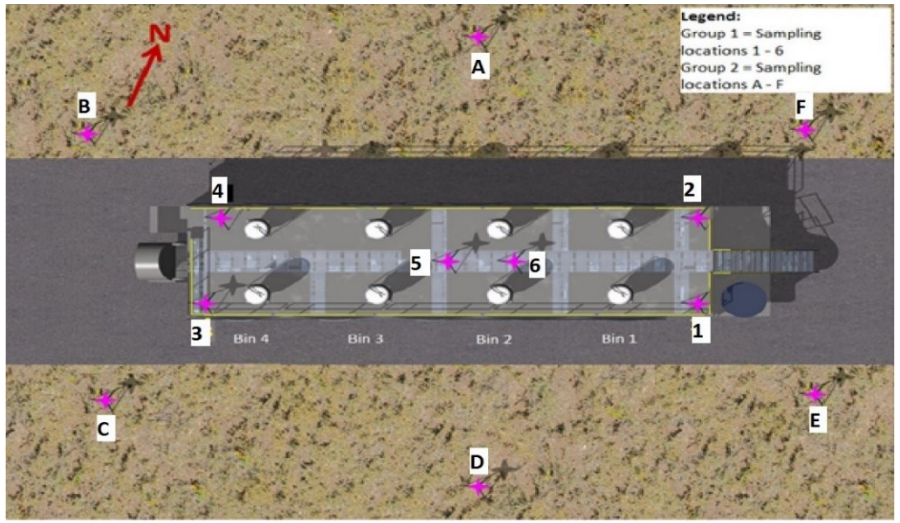


Cauda et al. 2018: https://doi.org/10.1080/15459624.2018.1495333

2013- Effectiveness of Mini Baghouse Retrofit Assembly for sand-movers

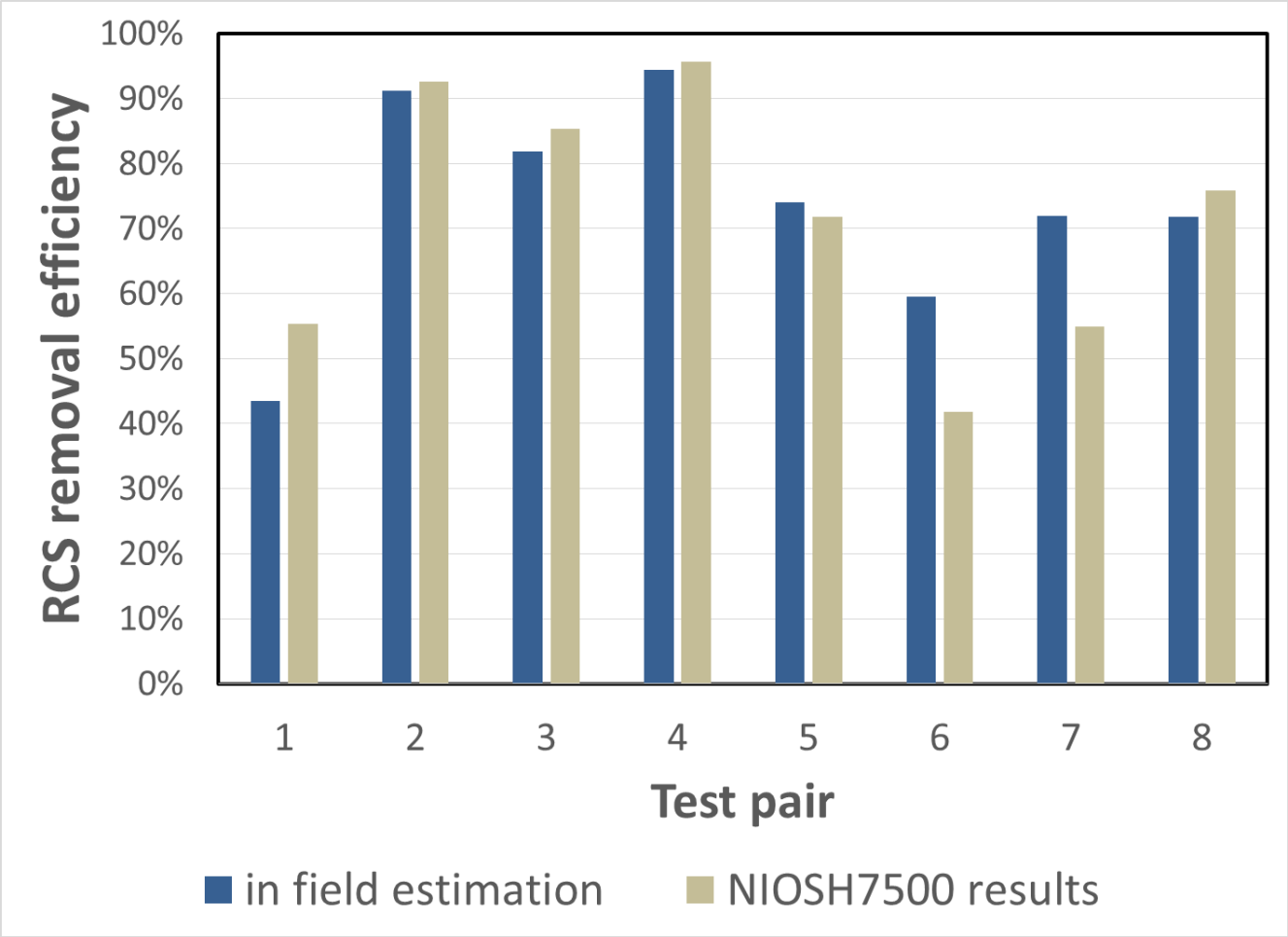
The mini-baghouse was field tested at a Sand mine in Arkansas (2013)

- Respirable dust samples collected on and around the sand mover with and without the mini-baghouse (overall 198 samples in 16 test). Each test lasted 45 minutes
- Samples analyzed in the field for RCS and then at the lab



Alexander, B. M., et al. (2018). "Evaluation of an improved prototype mini-baghouse to control the release of respirable crystalline silica from sand movers." Journal of Occupational and Environmental Hygiene **15**(1): 24-37.

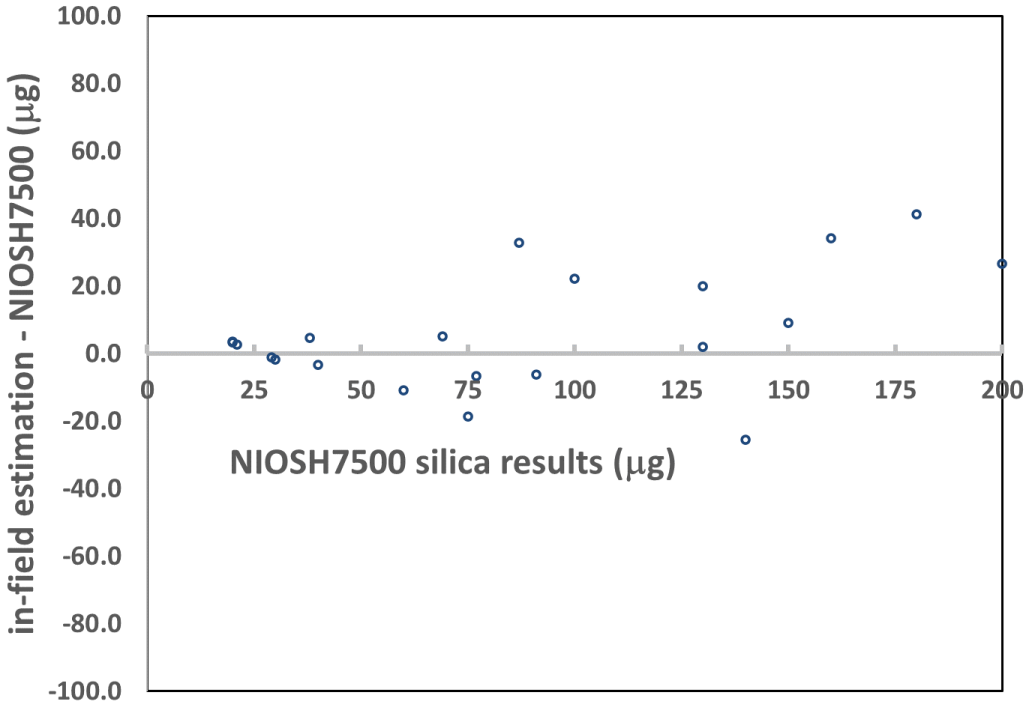
Effectiveness of Mini Baghouse Retrofit Assembly for sand-movers



- The field-based evaluation of the performance of the minibag houses provided comparable information with the NIOSH7500 method.
- Field-based approach results available in few minutes
- NIOSH7500 results available in few weeks.
- Adjustment to the minibag houses were possible thanks to the information generated on site by the field-based RCS monitoring approach

2017 - Texas sand fracking site beta testing during sand fracking

- Collected and analyzed 74 respirable dust samples in 4 days by industrial hygienist on site
- 37 samples showed levels of silica above limit of quantification (15 μg).
- Samples with a silica level lower than 200 μg/m3 were compared to the NIOSH 7500 method.
- The average difference between the two methods was 6 μg – relative difference is 5%



2019 – Assessment and characterization of silica in a sandstone quarry

Two site visits

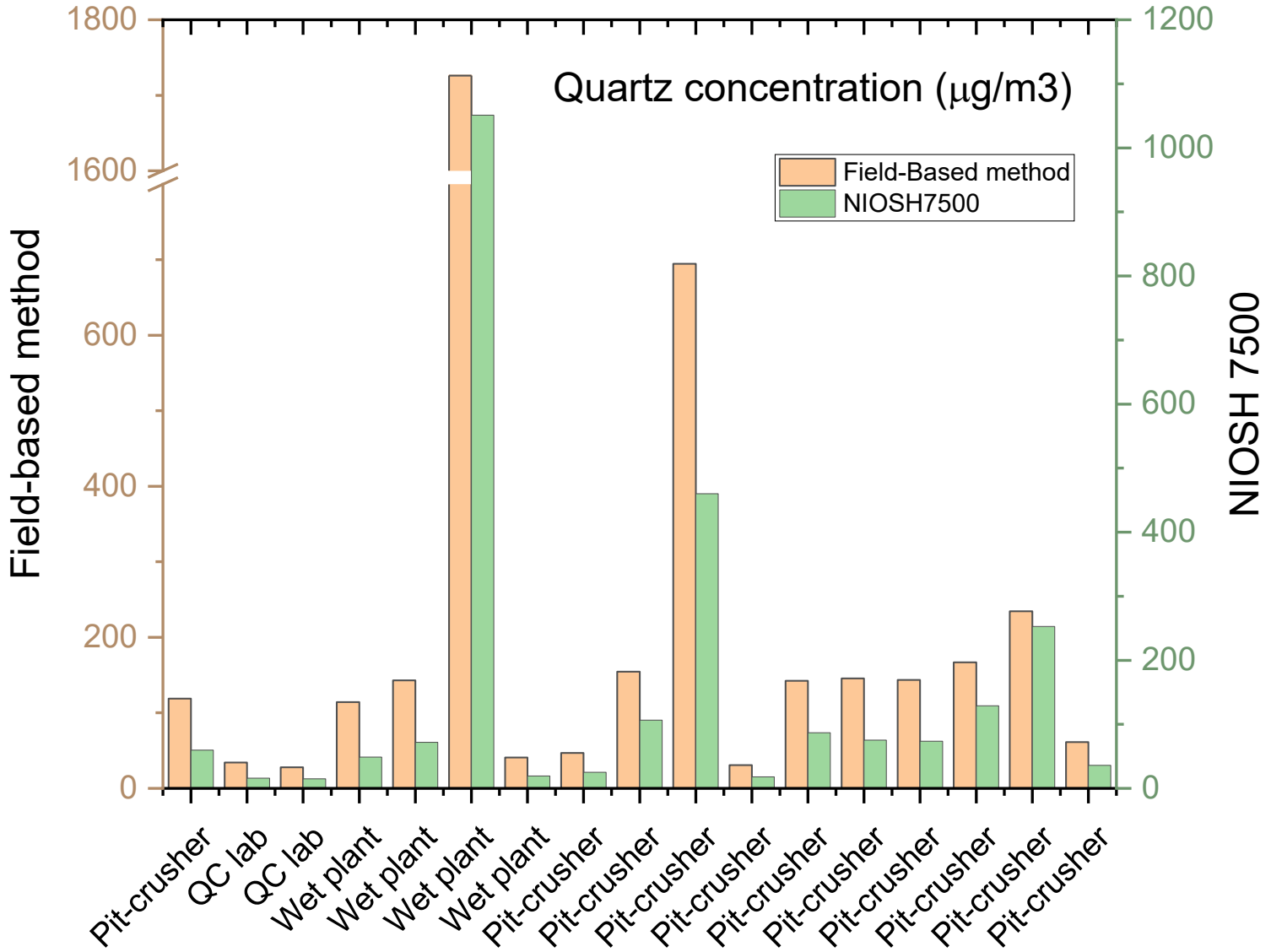
Area samples (41 samples)

- Respirable samplers and sampling pump
- Collection time – up to 7 hours

Three main areas selected – dry area (pit, crushers), wet plant, and Quality Control lab

2019 – Assessment and characterization of silica in a sandstone quarry

How was the performance of the field-based approach to estimate quartz in area respirable dust samples?



The field-based method overestimated the silica concentration of 40% (avg).

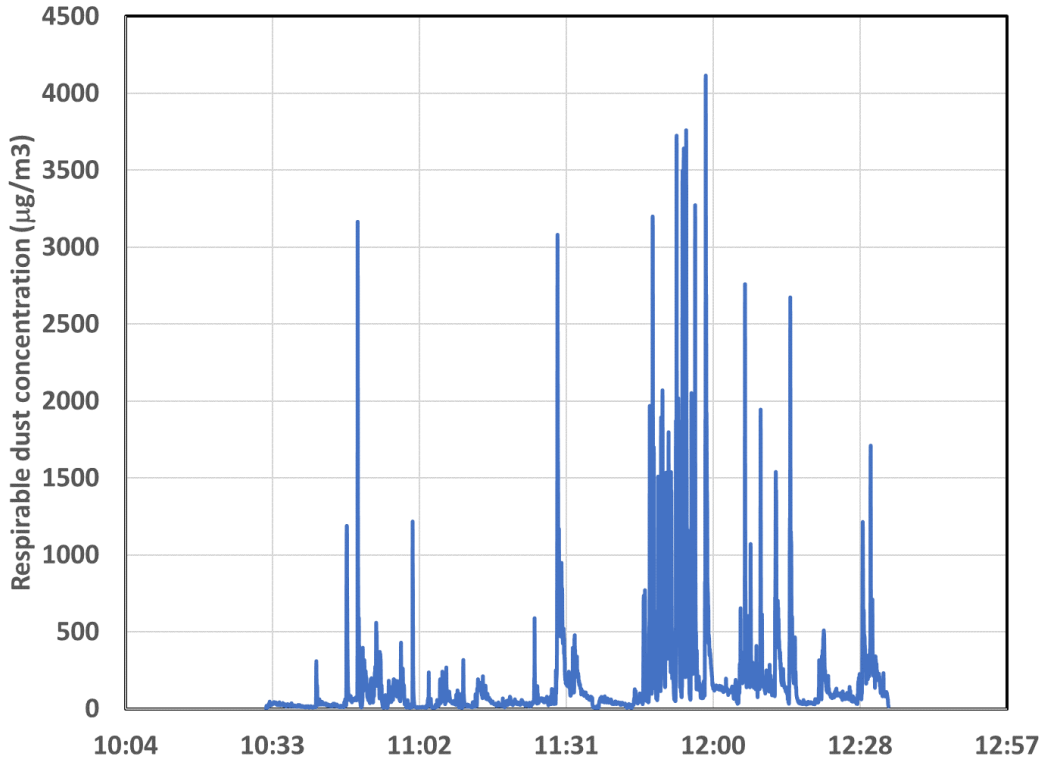
- *The field- based method followed the same trend of concentrations*

- *Possibility to create a site- specific correction factor*

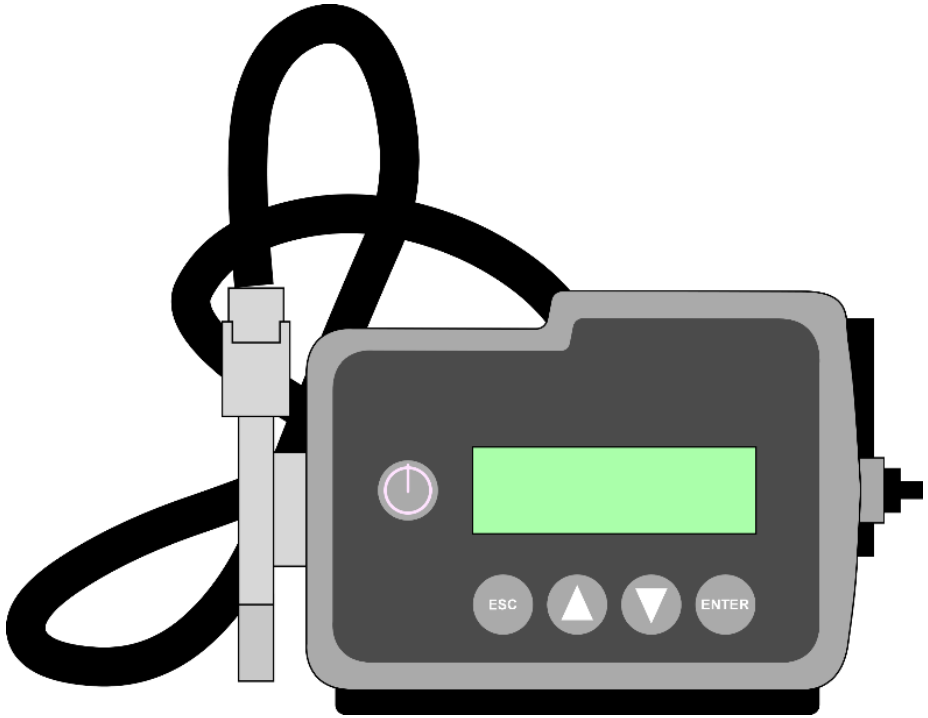
Real-time respirable dust monitors

- There is an increased interest in respirable dust monitors because of the OSHA silica rule. *Urgency.*

- While these monitors are familiar tools, they can be easily misused. *Importance of correct practice.*



Components of real-time respirable dust monitors

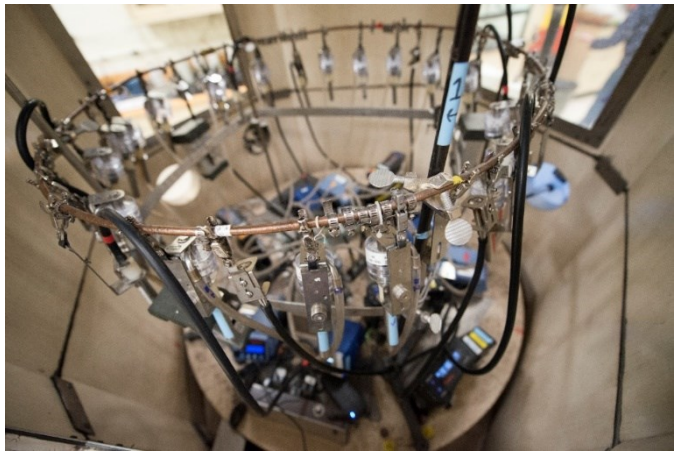


- *Size selector*
- *Sensing technology*
- *Filter media (optional)*
- *Sampling pump*

It is important to understand each component and to know the capabilities and limitations of the monitor

Calm air chamber used to assess real-time respirable dust monitors
Evaluation of correction factors with different dust material

	PTI ARD Fine	PTI ARD Course	Sand mine dust	Metal mine dust	Silica	Limestone mine dust
pDr1000	1.46	1.49	1.70	2.05	1.46	1.43
pDr1500	1.52	1.58	1.67	1.87	1.52	1.39
AM520	0.83	0.92	0.99	1.17	0.89	0.77

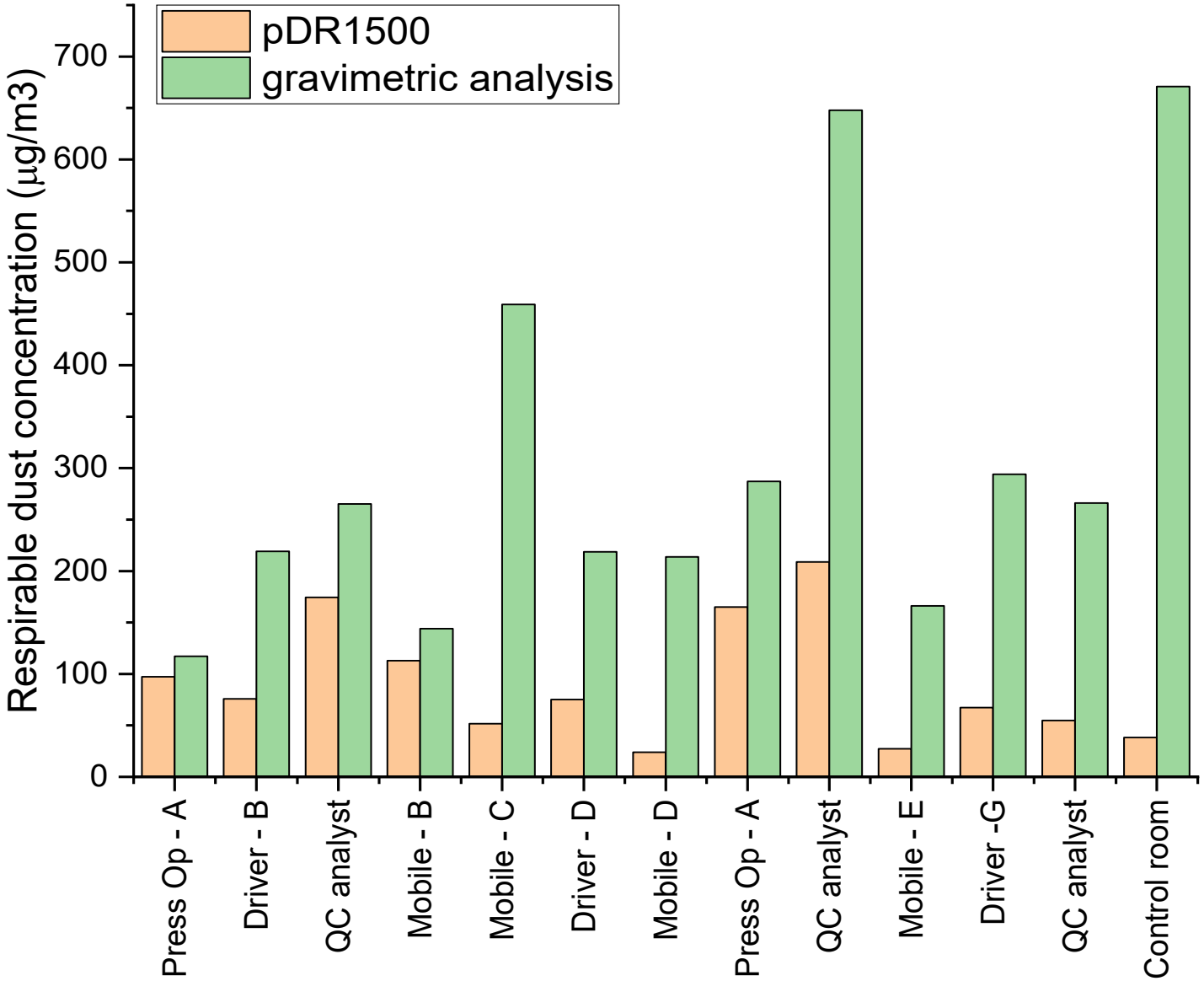


Even for factory-calibrated respirable dust monitors, the response to different dusts can be quite different

Patts JR, Tuchman DP, Rubinstein EN, Cauda EG, Cecala AB (2019) Performance comparison of real-time light scattering dust monitors across dust types and humidity levels. Mining, Metallurgy & Exploration (MME) Journal 36(4):741–749

2019 – Assessment and characterization of silica in a sandstone quarry

How was the performance of the real-time respirable dust monitors to estimate average concentration?



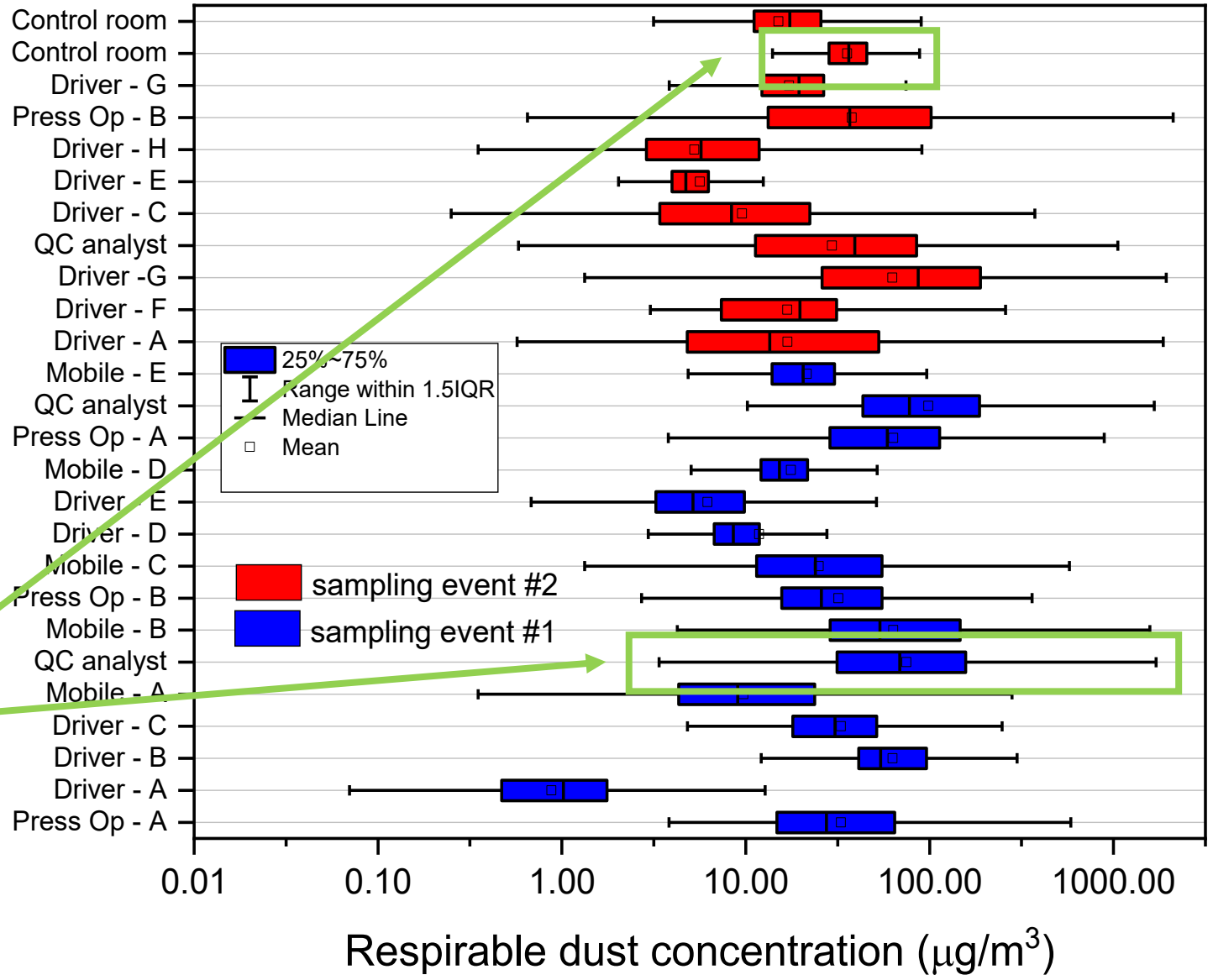
Correction factor varied from 1.2 to 17.

Silica content in the quarry dust varied from 20% to 90%

2019 – Assessment and characterization of silica in a sandstone quarry

- We can obtain more information from real-time respirable dust monitors than simply average concentration levels
- The concentration levels for mobile workers and inside the cabs are similar for October 2018 (blue) and July 2019 (red).

The data distribution for each session can provide information on the variability of the levels within the session.

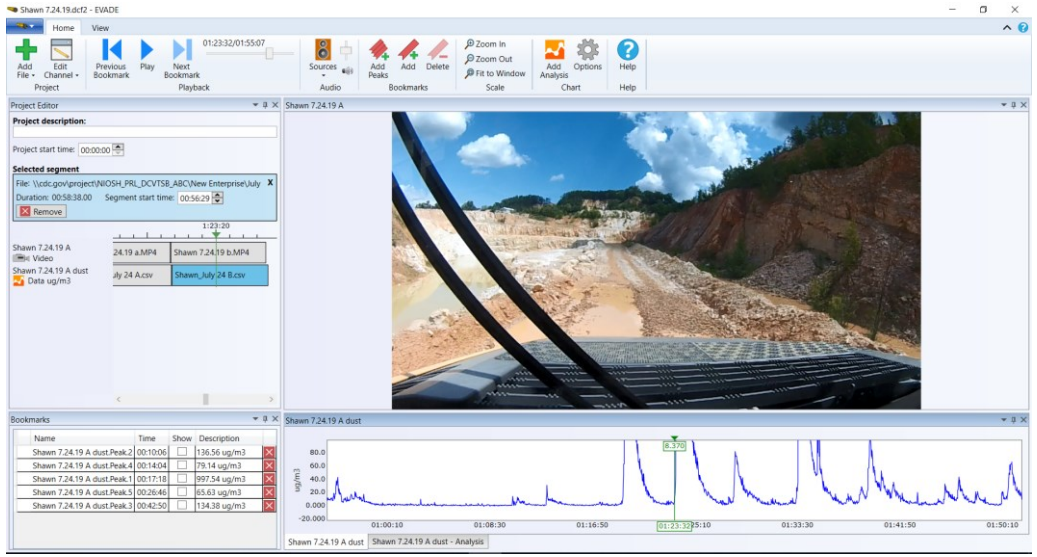


Real-time respirable dust monitors + webcam = Helmet-CAM

Evaluation tool to identify "sources of exposure" and to assess "control technology effectiveness"

- Video of tasks performed by worker along with respirable dust exposure monitoring
- Particularly suitable for mobile workers with multiple tasks
- *Goal* - develop control technologies to minimize areas of elevated exposures

NIOSH designed the EVADE software
http://www.cdc.gov/niosh/mining/Works/coversheet1867.html



Low-Cost Aerosol Monitors

What are they? Devices for area monitoring only (for now?)

Other names? Consumer aerosol monitors; Air quality monitors

What do they measure? PM2.5, PM10 - not exactly IH measures

What's inside the box? light scattering sensors or Optical Particle Counters

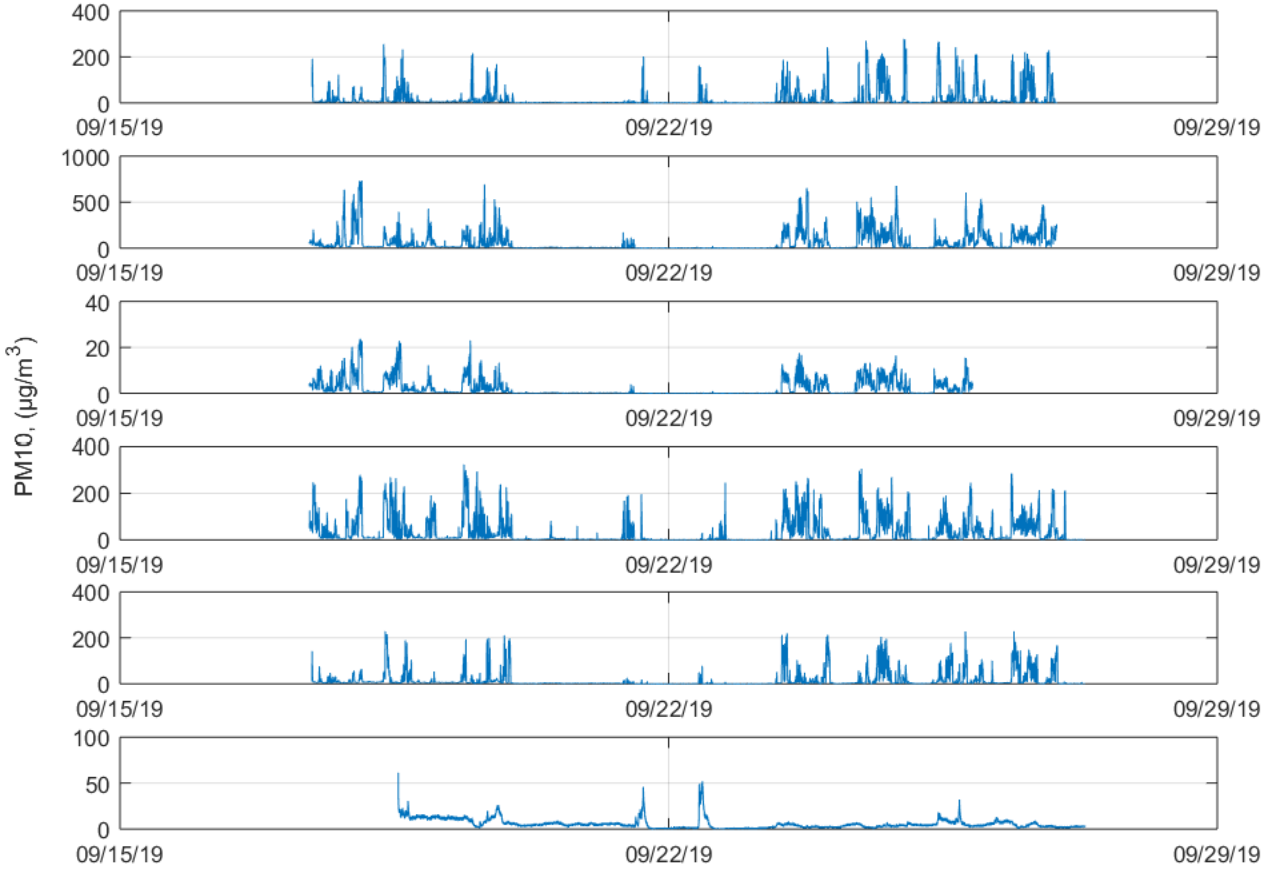
How accurate are they? It depends on the sensor inside (*and the math model*)

Cost? Less than $1000 (plus cloud service)

Strength? The possibility to use multiple units at the same time

Low-Cost Aerosol Monitors

Possible application - mapping



Research question: Can an array of low-cost aerosol monitors be used to adjust an industrial process if needed to secure healthy conditions for the workers – *Process control*

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Summary and final remarks

- The traditional approach for silica monitoring in the oilfield and in any workplace is accurate and effective. But there are limitations

- Advanced silica monitoring approaches can provide more timely information; these approaches can also assess the evolution of silica concentration in time and the spatial variability too.

- The use of a portable FTIR for a field-based silica monitoring approach can be an effective complementary tool to accelerate the generation of information for decision making. The accuracy needs to be assessed. NIOSH can support operators who are interested to adopt the field-based silica monitoring approach

- Respirable dust monitors can help assessing the variability of the dust concentration in time. The accuracy of these tools and the variability of silica in the dust should be considered. The Helmet-CAM can provide another level of information. NIOSH can help operators with the HELMET-CAM approach

- Low-cost dust sensors will allow to have temporal and spatial variability assessment of aerosol concentration. With proper data processing and modeling can help in automating control technologies. NIOSH is working in exploring the use of low-cost dust sensors

- The proper selection and knowledge of each methodology is essential to generate useful information. The industrial hygienist is still the smartest sensor even in an IH 4.0 world.

Questions?

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